Development of educational content for the
"D3MOBILE Metrology World League" Ed. 2020-2021

PROJECT REPORT

Project staff

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Presentation and objectives

The D3MOBILE Metrology World League is one of the funded projects within the 2020 *Education and Capacity Building Initiatives* program promoted by the International Society of Photogrammetry and Remote Sensing – ISPRS. Presented as an international championship, D3MOBILE is a consolidated initiative that introduces secondary students (grades ISCED 1 and 2) to the disciplines of photogrammetry and metrology through the e-learning methodology concept. This project is aligned with the mission of Technical Commission V, being the primary objective of D3MOBILE the support of capacity building at pre-university level. The use of well-known technologies by the students, such as their own mobile devices (smartphones or tablets) and free photogrammetric apps, allows us to develop educational procedures based on digital photogrammetry that are attractive and challenging for them. We tried to create and improve a project-based learning (PBL) methodology that can be adapted to daily classwork at the high school level, which can be easily implemented regardless of the number of participants and can be implemented anywhere in the world. The use of mobile applications for reality-based digitization and working with photogrammetric models have been shown to reinforce students' 3D spatial skills. All the work that we propose for the participants is presented in a scientific, technical, and professional language but in a more interactive format than traditional textbooks or theoretical classes. Particularly, the contents of the trials that we proposed are designed to cover

key topics like the photogrammetric principles, common problems for this technique (e.g. reflective objects and blurring), model texturing, 3D coordinate systems and precision/accuracy concepts.

Another purpose of the project is the promotion of Geomatics and Geoinformation sciences career enrolments. Academics and institutions involved in the fields of photogrammetry, remote sensing and spatial information sciences have been aware of a general worldwide decline in the number of undergraduates embarking on degree programmes in geomatics. The current difficulty in attracting students is making departments and programmes less viable, and there is a serious risk that a number of these smaller departments or programmes will be threatened with closure. Paradoxically, graduates in the spatial sciences have never been in such high demand by the professional market, as the role of spatial information in society has been well documented. The results of the first editions of D3MOBILE demonstrate the potential of alternative teaching methods combined with new technologies to engage students in science learning and improve the perception of the geosciences as a job opportunity.

Implementation

The "D3MOBILE Metrology World League" project was carried out over an 8-year period (2013–2020), and we are currently preparing the next edition 2021, which is expected to be launched during the next month. The e-learning nature of the project was designed to reach as many pupils as possible. All the necessary reference material (e.g., methodology, quizzes and championship guidelines) is available online for the participants. The D3MOBILE championship website (**http://www.d3mobile.es/index.php?idioma=en**) constitutes the main source of communication with students and teachers. We use the web to upload publications and videos from schools and to feature satisfaction inquiries, information about the championship and relevant or remarkable scientific information.

Before the start of each school year, we open a registration period during which a teacher, who will lead one or several groups of 3 or 4 students each, should register. After registration, each teacher will have access to our content and methodological guides so that they can implement this process in their classes. The structure of the championship in three independent trials makes it possible for teachers to decide how far to proceed with their students based on the teaching plan for each subject and each high school.

(1) First quiz

The first exercise has a formative and self-evaluative nature. At the content level, this exercise introduces the concept of photogrammetry and allows students to become familiar with 3D modelling techniques with the use of their own smartphone/tablet. The modelling of a common object is proposed for all teams. In the corresponding guide to the quiz, each group is provided with different basic techniques to improve the quality and stabilization of its images. Using this guide and help from their teachers, the participants set the configuration of the device parameters and take photographs of the object. Then, using these images and free software (e.g., Trnio, Scann3D or Arc3D), students can generate their own 3D model.

Fig. 1. Students participating in the introductory session to learn about mobile-based 3-D digitization.

(2)   Second quiz

The objective of the second quiz is to use the knowledge acquired in the first introductory. For this purpose, the creation of a 3D model of an object of their own choice is proposed for each team. In addition to reinforcing theoretical concepts, this exercise allows students to develop their creativity. Furthermore, in the second part of this quiz, participants are introduced to the world of 3D editing, and they use specific computer tools designed for this purpose (e.g., Meshlab) to edit their own model. Finally, students carry out the publication of their model in an online repository for 3D models (e.g., Sketchfab.com), which allows them to disseminate their model to the general public and to their personal social circle through social networks.
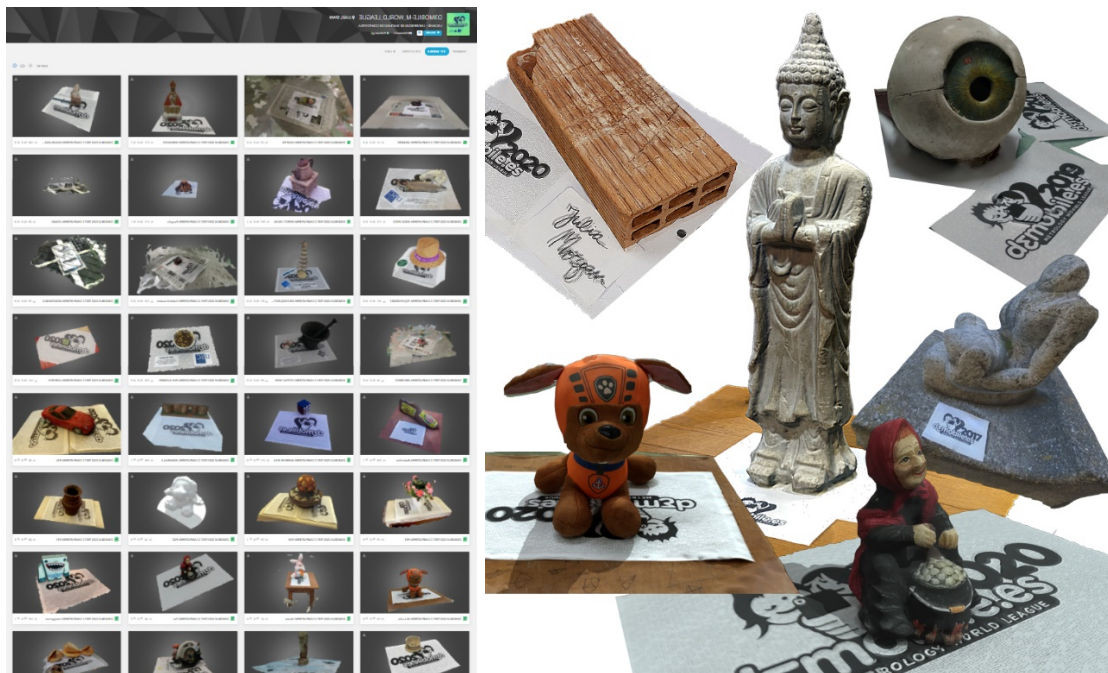

Fig. 2. Some 3D objects digitized by the students. More examples are available on Sketchfab (https://sketchfab.com/d3mobile-m_world_league).

(3) Third quiz

The last test is focused on the metric assessment of 3D models. In the first part of the quiz, some basic concepts associated with metrology, such as accuracy, precision, and error or measurement uncertainty, are reviewed with practical examples. The second part of the test involves the scaling, from a well-known reference distance, of a photogrammetric model created by the staff of the championship.

The D3MOBILE project has been designed to adapt to e-learning methodology in a way that is compatible with the daily work at the high school level and can thus be directly incorporated into students' curriculum. However, in addition to the provided tests, we also make available a set of tools (e.g., guides, discussion forums or video tutorials) and activities to students and teachers that facilitate their work. The teaching materials are organized in a way that allows a single teacher to supervise up to six teams of four students each. In this way, the project can be integrated into classwork, either as voluntary or mandatory work, within a given lesson plan.

Outcomes

CAPACITY BUILDING

The design of the project is based on highlighting the skills that a STEM professional should possess. In this sense, the championship is designed as a team competition to reinforce the brainstorming capacity and teamwork of the pupils. These pupils are intended to develop their **analytical capacity by solving problems**. Although we provide them with the detailed documentation of the trials that should allow for autonomous work, they have to solve the problem together.

Fig. 3. Students developing their capacity of solving problems and building strategies to improve their results.

We also try to design the championship tools to allow the students to improve their **communication skills**. On the other hand, the ability to visualize in three dimensions is a cognitive skill that has been shown to be important in engineering and other technological fields. The use of mobile applications for reality-based digitization and working with photogrammetric models have been shown to reinforce students' **3D spatial skills**.

Promoting science is critical because important and broadly used advances are often beyond society's understanding. The D3MOBILE project has been designed to **enhance interest in the sciences** and particularly the geosciences by highlighting the professional possibilities offered by photogrammetry and the use of 3D techniques in many fields. To achieve this goal, it is essential to present theoretical and practical content related to these fields in an attractive way.

Particularly, the contents of the three trials are designed to **enrich the students' curricula the following topics**:

- Photogrammetry principles.

- Common problems of photogrammetry (e.g., reflective objects, blurring).

- Point clouds and TIN surface representation.

- Model texturing.

- Object transformations, including translation, scaling, rotation, and reflection.

- 3D coordinate systems.

- The concepts of accuracy/precision, uncertainty and error.

However, this system is also designed to encourage students to disseminate their own work to get votes, which can attract the attention of their entire social network. This project is also expected to allow students to **reinforce their vocational choice** by influencing their environment.

METHODOLOGICAL OUTCOMES

With the editions 2020 and 2021 of the D3MOBILE, we intended to consolidate this international championship as a benchmark in the integration of photogrammetry within the STEM projects. ISPRS funding is mainly being used to continue **improving teaching and supporting materials,** making them more attractive and accessible for the participants. For this purpose, during this year, we have redesigned and translated the PDF guides of each one of the three tests, we have created a set of video tutorials and promotional videos, we have optimized the website (www.d3mobile.es) for different platforms/operating systems and we have improved its overall navigation and content, among other activities.

The next edition of D3MOBILE already has the entire collection of materials available in at least three languages (English, Spanish and Italian) with professional (human) translation. We have also integrated the Google translator tab on the website for automatic translation into many other languages, which is obviously less precise but can also be helpful in certain cases. These

improvements will undoubtedly contribute to improve the participant's experience and to achieve greater internationalization.
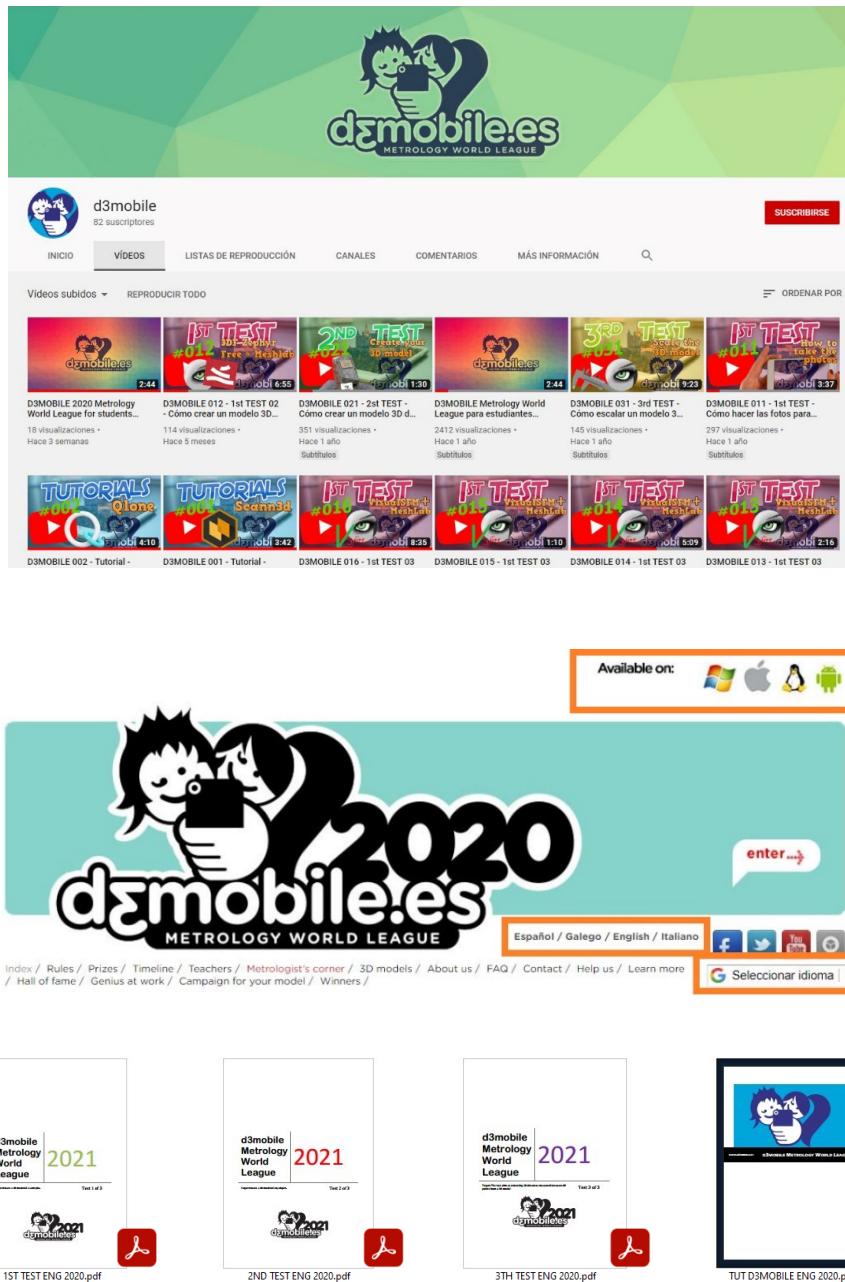

Fig. 4. Set of video tutorials (available on YouTube: https://www.youtube.com/channel/UCcQUY1pbMi_NJp-Kz-rkB1A); main improvements of the website (www.d3mobile.es) and translations; and PDF guides (downloadable from the website after registration)

IMPACT AND DISSEMINATION RESULTS

The **impact** of the project is assessed through quantitative criteria based on the number of registered teams (engagement) and the number of participating countries (internationalization). The D3mobile 2020 has registered the participation of 496 students and 120 teachers from 99 high schools and 17 countries. 29 teams managed to reach the final phase of the championship after completing the three tests. Despite the influence that the pandemic situation has had on the

development of this school year, the levels of participation in the D3MOBILE have been close to those achieved in other years.

The final **ceremony award** of each edition was usually held in June, so that the winning students and teachers would meet in the city of Lugo (Spain) to collect their prizes. The Covid-19 has disrupted our plans to hold a face-to-face ceremony for the winners this year. However, we hope that the 2021 edition, which will start soon, can be held as normal. The PIs of the project and other the co-investigators from UNIFI and USC will conduct the event and present the results of the championship. Taking the opportunity to meet international experts and children, we are also considering carrying out a brief **training event** or a 3D Hackathon during this day.

Fig. 5. Some of the previous winners receiving their prizes.

In addition, we have participated in the virtual event of the XXIV ISPRS Congress, contributing with two **conference papers** related to photogrammetry education and capacity building (see *Project related references* section):
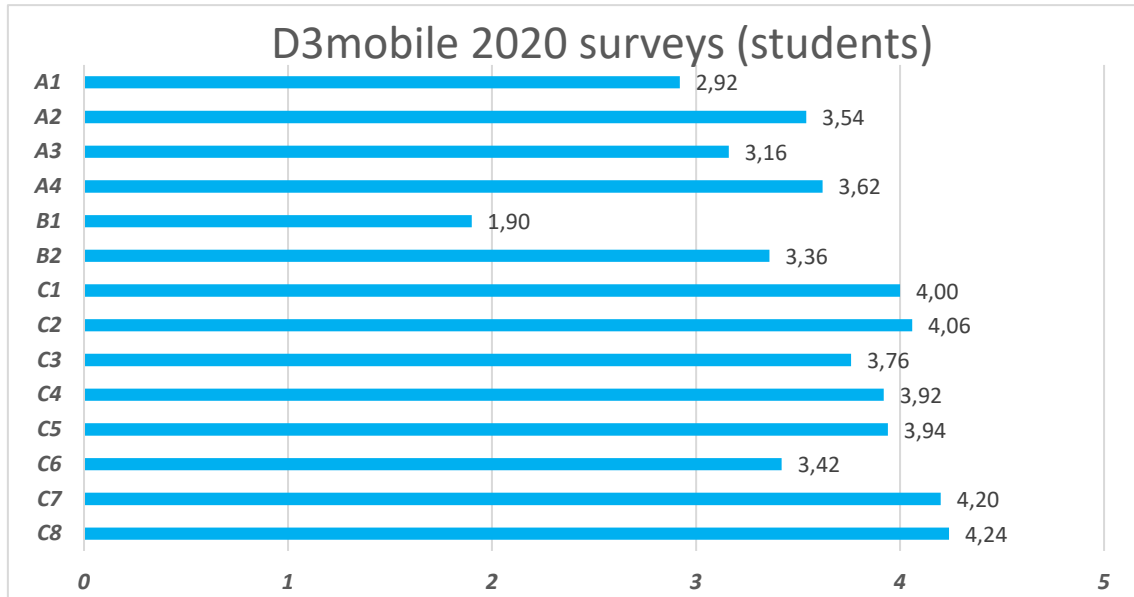
- Tucci et al. (2020), that addresses the issue of implementation of multimedia materials (updated and engaging resources, as videos, tutorials, and datasets) to be used during courses, workshops, and seminars targeted to different user groups.

- Ortiz-Sanz et al. (2020), that specifically presents the D3MOBILE as a Project Based e-Learning initiative, which implements an educational procedure for secondary students using smartphone-based 3-D scanning techniques.

SATISFACTION SURVEYS

As every year, at the end of the 2020 D3MOBILE edition, feedbacks have been requested from students and teachers using the following opinion surveys.

D3MOBILE SURVEY: STUDENTS	
Please rank your satisfaction level from 1 (not agree) to 5 (totally agree) in the following aspects.	
A	**Interest in science and technology:**
A1	I had little or no interest in Science, Technology, Engineering and / or mathematics before participating in the D3MOBILE
A2	I did not know that I could be a professional 3D modeller before participating in the D3MOBILE
A3	D3MOBILE has increased my interest in and my fondness for science.
A4	D3MOBILE has increased my interest in and my fondness for technology.
B	**Level of ISPRS dissemination among the students:**
B1	Before participating in the D3MOBILE I knew the work of the ISPRS (*International Society of Photogrammetry and Remote Sensing*)
B2	After participating in the D3MOBILE I know the work of the ISPRS (*International Society of Photogrammetry and Remote Sensing*)
C	**Specific aspects of D3MOBILE:**
C1	The exercises are well presented.
C2	The material is accessible and adequate.
C3	The guides explain the exercises in a clear and easy to understand way.
C4	The software applications are simple and accessible.
C5	There is enough time to carry out the tests.
C6	The D3MOBILE website and forum are truly helpful.
C7	The advice and counselling provided by the organizers is adequate.
C8	The D3MOBILE awards are appealing
D	**Satisfaction level with D3MOBILE** (I would participate again in the D3MOBILE and I would recommend my classmates to do so as well)
E	**Observations: (What do you think could be changed/improve in future competitions?)**

D3mobile 2020 surveys (students)

Code	Value
A1	2,92
A2	3,54
A3	3,16
A4	3,62
B1	1,90
B2	3,36
C1	4,00
C2	4,06
C3	3,76
C4	3,92
C5	3,94
C6	3,42
C7	4,20
C8	4,24

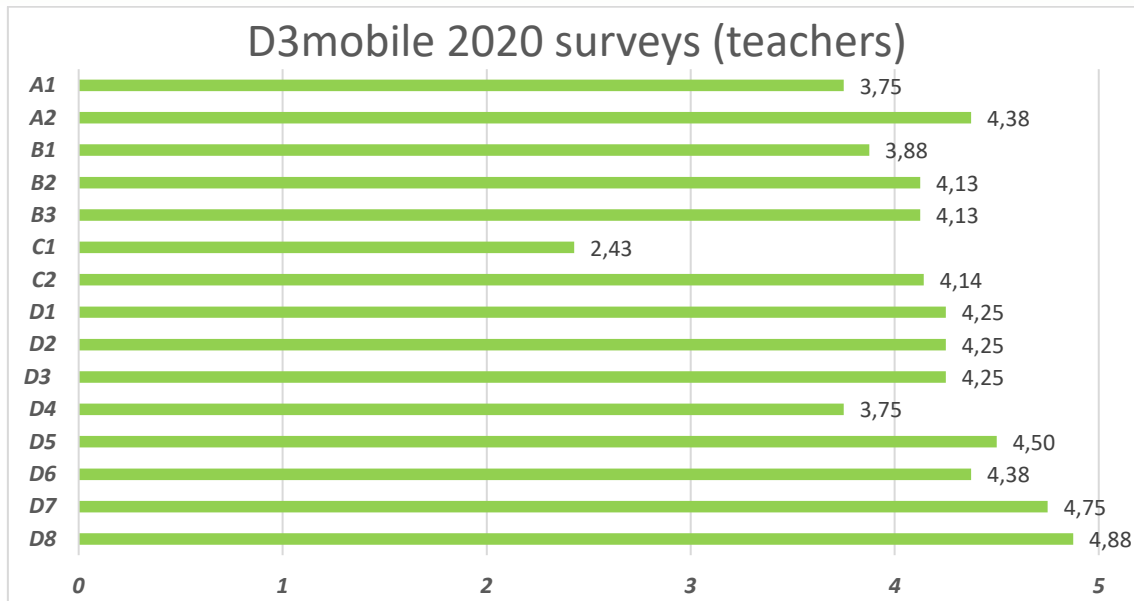|	D3MOBILE SURVEY: TEACHERS
	Please rank your satisfaction level from 1 (not agree) to 5 (totally agree) in the following aspects.
A	**Impact on interest on scientific subjects**
A1	Students who participated in the D3MOBILE now show higher interest in scientific subjects (Physics, Chemistry, Math, etc.)
A2	Students who participated in the D3MOBILE now show higher interest in technological subjects (ICT, Technology, Drawing, etc.)
B	**Impact on academic results in scientific subjects**
B1	Thanks to their participation in the D3MOBILE students have obtained better academic results in scientific-technological subjects than in previous years.
B2	I think the D3MOBILE has increased/awaken students' interest in university scientific-technological courses
B3	I think the D3MOBILE captures the attention of students who are usually less willing to work
C	**Level of ISPRS dissemination among the teachers:**
C1	Before participating in the D3MOBILE I knew the work of the ISPRS (*International Society of Photogrammetry and Remote Sensing*)
C2	After participating in the D3MOBILE I know the work of the ISPRS (*International Society of Photogrammetry and Remote Sensing*)
D	**Specific aspects of the D3MOBILE:**
D1	The exercises are well presented.
D2	The material is accessible and adequate.
D3	The guides explain the exercises in a clear and easy to understand way.
D4	The software applications are simple and accessible.
D5	There is enough time to carry out the tests
D6	The D3MOBILE website and forum are truly helpful.
D7	The advice and counselling provided by the organizers is adequate.
D8	The D3MOBILE awards are appealing
E	**Satisfaction level with D3MOBILE (I would participate again in the D3MOBILE and I would recommend my students and colleagues to do so as well)**
F	**Observations: (What do you think could be changed/improve in future competitions?)**

Fig. 6. Survey tables provided to students and teachers of the 2020 D3MOBILE edition and the respective feedback results

The "D3MOBILE Metrology World League" demonstrates that although students may be initially interested in science, some concepts and techniques, such as some of those included in this project, can be difficult to teach. Student surveys reveal that the **synergy between science and new technologies** can remarkably improve their perceptions of both fields.

From the teachers' standpoint, the results were also definitively positive. Teachers observed a general increase in interest in science and a better understanding of concepts compared to those of students in previous school years, who were taught only using standard lecture instruction. In their opinion, the overall student involvement was remarkable, and it was particularly notable for students who had been observed to have had poor interactions within groups in other circumstances.

It is also gratifying to see that in the open questions (F) participants recognize in general that they have **learned about "metrology", "photogrammetry" and "3-D".** These are some typical quotes:

"We believe that the championship is well planned since it is accessible to everyone who wants to participate and opens up new possibilities for many young people who want to know more about 3-D scanning with mobile phones".

"We enjoyed doing this activity because we think it encourages teamwork and it allows to learn about metrology in a more pleasant way".

"I think it's an excellent initiative to promote photogrammetry. I loved knowing the process of 3-D modeling and its applications".

D3MOBILE is also helping to **publicize the ISPRS mission and activities** towards pre-university students with potential interests in geoscientific disciplines. In this regard, we have

included among participants' tasks certain questions that require them to seek information about ISPRS and its work. This fact will further improve the international status of the ISPRS and will therefore benefit all members of the Society. The surveys included specific questions related to the assessment of the level of ISPRS dissemination among the participants, before and after their participation in the D3MOBILE.

Conclusions

The levels of participation and internationalization achieved by this project allow us to be optimistic about future editions of D3MOBILE. Several factors, such as the e-learning format, the structure of a concept submission competition and the development of innovative materials, have contributed to the dissemination of this championship and the engagement of students. Thus, we will continue to use this experience as a reference for future projects.

Furthermore, the D3MOBILE project allows us to improve the awareness and visibility of some scientific fields, including photogrammetry and metrology, thus changing students' perceptions of them.

Project related references

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Organizers

Sponsors